CLAIMS

What is claimed is:

1. A reinforcing fiber substrate formed by at least a reinforcing fiber yarn group arranged with continuous reinforcing fiber yarns in parallel to each other in one direction, characterized in that a resin material whose main constituent is a thermoplastic resin is provided at 2 to 15 % by weight at least on one surface of said reinforcing fiber substrate, and the reinforcing fiber volume fraction V_{pf} of said reinforcing fiber substrate calculated from a thickness of said reinforcing fiber substrate, which is determined based on JIS-R7602, is in a range of 40 to 60 %.

2. The reinforcing fiber substrate according to claim 1, wherein the yield of said reinforcing fiber yarn is in a range of 350 to 3,500 tex, the number of filaments of said reinforcing fiber yarn is in a range of 6.000 to 50,000, said substrate is formed by said reinforcing fiber yarn group and a weft-direction auxiliary yarn group in which continuous auxiliary yarns extend in a direction across said reinforcing fiber yarns, and said substrate is a unidirectional reinforcing fiber substrate the areal weight of reinforcing fiber yarns of which is in a range of 120 to 320 g/m^2.

3. The reinforcing fiber substrate according to claim 1, wherein said substrate has a warp-direction auxiliary yarn group formed by auxiliary yarns extending in a direction parallel to said reinforcing fiber yarns, and the yield of the auxiliary yarn forming said warp-direction auxiliary yarn group is 20 % or less of the yield of said reinforcing fiber yarn.

4. The reinforcing fiber substrate according to claim 1, wherein said substrate has a warp-direction auxiliary yarn group formed by auxiliary yarns extending in a direction parallel to said reinforcing fiber yarns, a weft-direction auxiliary yarn group is disposed on each surface of said substrate, and said substrate is formed as a unidirectional noncrimp woven fabric the weave structure of which is formed by auxiliary yarns forming said warp-direction auxiliary yarn group and auxiliary yarns forming said weft-direction auxiliary yarn group.

5. The reinforcing fiber substrate according to claim 1, wherein a mean gap between adjacent reinforcing fiber yarns is in a range of 0.1 to 1 mm.

6. The reinforcing fiber substrate according to claim 1, wherein said resin material is studded on a surface of said reinforcing fiber substrate, a mean diameter of said studded resin material on the surface of said reinforcing fiber substrate, viewed in plane, is 1 mm or less, and a mean height of said studded resin material from the surface of said reinforcing fiber substrate is in a range of 5 to 250 μm.

7. The reinforcing fiber substrate according to claim 1, wherein said resin material adheres to said reinforcing fiber substrate at a fiber-like condition.

8. The reinforcing fiber substrate according to claim 3, wherein a sizing or collecting treatment is performed on auxiliary yarns forming said warp-direction auxiliary yarn group.

9. The reinforcing fiber substrate according to claim 1, wherein, when a composite material is molded using said reinforcing fiber substrate and the section of the composite material perpendicular to an extending direction of reinforcing fiber yarns is observed, a rate te/tc of a thickness of a reinforcing fiber yarn te at an end portion in the width direction of the reinforcing fiber yarn to a thickness of a reinforcing fiber yarn tc at a center portion in the width direction of the reinforcing fiber yarn is in a range of 0.3 to 1.

10. The reinforcing fiber substrate according to claim 1, wherein, when a composite material having a reinforcing fiber volume fraction of 53 to 65 % is molded, the composite material satisfies at least two of the following properties (a) to (d):

(a) a compressive strength at a room temperature after impact at an impact energy of 6.67 J/mm determined by a method defined in SACMA-SRM-2R-94 is 240 MPa or more;

(b) a non-hole compressive strength at a room temperature using a laminate having a lamination structure defined in SACMA-SRM-3R-94 is 500 MPa or more;

(c) a 0° compressive strength at a room temperature determined by a method defined in SACMA-SRM-1R-94 is 1,350 MPa or more, and a 0° compressive strength at a high temperature after a hot/wet conditioning determined by the method is 1,100 MPa or more; and (d) an open-hole compressive strength at a room temperature determined by a method defined in SACMA-SRM-3R-94 is 270 MPa or more, and an open-hole compressive strength at a high temperature

after a hot/wet conditioning determined by the method is 215 MPa or more.

11. The reinforcing fiber substrate according to claim 1, wherein said substrate is a reinforcing fiber substrate used for vacuum assisted injection molding.

12. The reinforcing fiber substrate according to claim 1, wherein said substrate is used for formation of a preform in which a plurality of substrates are stacked and integrated.

13. A composite material characterized in that said composite material is formed by impregnating a matrix resin into a reinforcing fiber substrate, which is formed by at least a reinforcing fiber yarn group arranged with continuous reinforcing fiber yarns in parallel to each other in one direction, in which a resin material whose main constituent is a thermoplastic resin is provided at 2 to 15 % by weight at least on one surface of said reinforcing fiber substrate, and in which the reinforcing fiber volume fraction V_{pf} of said reinforcing fiber substrate calculated from a thickness of said reinforcing fiber substrate, which is determined based on JIS-R7602, is in a range of 40 to 60 %, and the reinforcing fiber volume fraction V_f of said composite material calculated from a thickness of said composite material is in a range of 50 to 65 %.

14. The composite material according to claim 13, wherein a maximum cross-sectional waviness of a layer of a reinforcing fiber substrate in a section of said composite material is 0.3 mm or less.

15. A reinforcing fiber substrate characterized in that said reinforcing fiber substrate includes a reinforcing fiber yarn group arranged with reinforcing fiber yarns in parallel to each other in one direction and a weft-direction auxiliary yarn group formed by auxiliary yarns extending in a direction across said reinforcing fiber yarns and having a yield of 1 % or less of the yield of said reinforcing fiber yarn, and a resin material is provided at 0.5 to 20 % by weight at least on a surface of said reinforcing fiber substrate.

16. The reinforcing fiber substrate according to claim 15, wherein said substrate has a warp-direction auxiliary yarn group formed by auxiliary yarns extending in a direction parallel to said reinforcing fiber yarns, and the yield of the auxiliary yarn forming said warp-direction auxiliary yarn group is 20 % or less of the yield of said reinforcing fiber yarn.

17. The reinforcing fiber substrate according to claim 15, wherein said substrate has a warp-direction auxiliary yarn group formed by auxiliary yarns extending in a direction parallel to said reinforcing fiber yarns, a weft-direction auxiliary yarn group is disposed on each surface of said substrate, and said substrate is formed as a unidirectional noncrimp woven fabric the weave structure of which is formed by auxiliary yarns forming said warp-direction auxiliary yarn group and auxiliary yarns forming said weft-direction auxiliary yarn group.

18. The reinforcing fiber substrate according to claim 15, wherein a mean gap between adjacent reinforcing fiber yarns is in a range of 0.1 to 1 mm.

19. The reinforcing fiber substrate according to claim 15, wherein said resin material is studded on a surface of said reinforcing fiber substrate, a mean diameter of said studded resin material on the surface of said reinforcing fiber substrate, viewed in plane, is 1 mm or less, and a mean height of said studded resin material from the surface of said reinforcing fiber substrate is in a range of 5 to 250 μm.

20. The reinforcing fiber substrate according to claim 15, wherein said resin material adheres to said reinforcing fiber substrate at a fiber-like condition.

21. The reinforcing fiber substrate according to claim 16, wherein a sizing or collecting treatment is performed on auxiliary yarns forming said warp-direction auxiliary yarn group.

22. The reinforcing fiber substrate according to claim 15, wherein, when a composite material having a reinforcing fiber volume fraction of 53 to 65 % is molded, the composite material satisfies at least two of the following properties (a) to (d):

(a) a compressive strength at a room temperature after impact at an impact energy of 6.67 J/mm determined by a method defined in SACMA-SRM-2R-94 is 240 MPa or more;

(b) a non-hole compressive strength at a room temperature using a laminate having a lamination structure defined in SACMA-SRM-3R-94 is 500 MPa or more;

(c) a 0° compressive strength at a room temperature determined by a method defined in SACMA-SRM-1R-94 is 1,350 MPa or more, and a 0° compressive strength at a high temperature after a hot/wet conditioning determined by the method is 1,100 MPa or more; and (d) an open-hole compressive strength at a room temperature determined by a method defined in SACMA-SRM-3R-94 is 270 MPa or more, and an open-hole compressive strength at a high temperature after a hot/wet conditioning determined by the method is 215 MPa or more.

23. The reinforcing fiber substrate according to claim 15, wherein said substrate is a reinforcing fiber substrate used for vacuum assisted injection molding.

24. The reinforcing fiber substrate according to claim 15, wherein said substrate is used for formation of a preform in which a plurality of substrates are stacked and integrated.

25. A composite material characterized in that said composite material is formed by impregnating a matrix resin into a reinforcing fiber substrate, which includes a reinforcing fiber yarn group arranged with reinforcing fiber yarns in parallel to each other in one direction and a weft-direction auxiliary yarn group formed by auxiliary yarns extending in a direction across said reinforcing fiber yarns and having a yield of 1 % or less of the yield of said reinforcing fiber yarn, and in which a resin material is provided at 0.5 to 20 % by weight at least on a surface of said reinforcing fiber substrate, and the reinforcing fiber volume fraction V_f of said composite material calculated from a thickness of said

composite material is in a range of 50 to 65 %.

26. The composite material according to claim 25, wherein a maximum cross-sectional waviness of a layer of a reinforcing fiber substrate in a section of said composite material is 0.3 mm or less.

27. The composite material according to claim 25, wherein the cross-sectional area of said weft-direction auxiliary yarn is 1/50 or less of the cross-sectional area of said reinforcing fiber yarn.

28. A reinforcing fiber substrate comprising a reinforcing fiber group arranged with reinforcing fiber yarns in parallel to each other in one direction, characterized in that spacer yarns each having a concave/convex surface are arranged between said reinforcing fiber yarns, and a resin material is adhered at 2 to 20 % by weight at least to one surface of said reinforcing fiber group.

29. The reinforcing fiber substrate according to claim 28, wherein said substrate has a warp-direction auxiliary yarn group formed by auxiliary yarns extending in a direction parallel to said reinforcing fiber yarns, the yield of the auxiliary yarn forming said warp-direction auxiliary yarn group is 20 % or less of the yield of said reinforcing fiber yarn, and said spacer yarns are arranged as said warp-direction auxiliary yarns.

30. The reinforcing fiber substrate according to claim 28, wherein said substrate has a warp-direction auxiliary yarn group formed by auxiliary yarns

extending in a direction parallel to said reinforcing fiber yarns, a weft-direction auxiliary yarn group is disposed on each surface of said substrate, and said substrate is formed as a unidirectional noncrimp woven fabric the weave structure of which is formed by auxiliary yarns forming said warp-direction auxiliary yarn group and auxiliary yarns forming said weft-direction auxiliary yarn group.

31. The reinforcing fiber substrate according to claim 28, wherein a mean gap between adjacent reinforcing fiber yarns is in a range of 0.1 to 1 mm.

32. The reinforcing fiber substrate according to claim 28, wherein said resin material is studded on a surface of said reinforcing fiber substrate, a mean diameter of said studded resin material on the surface of said reinforcing fiber substrate, viewed in plane, is 1 mm or less, and a mean height of said studded resin material from the surface of said reinforcing fiber substrate is in a range of 5 to 250 μm.

33. The reinforcing fiber substrate according to claim 28, wherein said resin material adheres to said reinforcing fiber substrate at a fiber-like condition.

34. The reinforcing fiber substrate according to claim 28, wherein said spacer yarn is formed as a yarn in which at least two threads are twisted so that the surface of the yarn has a concave/convex form.

35. The reinforcing fiber substrate according to claim 28, wherein said spacer

yarn is formed as a covering yarn.

36. The reinforcing fiber substrate according to claim 28, wherein the ratio of maximum yarn width to minimum yarn width of said spacer yarn is 1.2 or more.

37. The reinforcing fiber substrate according to claim 28, wherein, when a composite material is molded using said reinforcing fiber substrate and the section of the composite material perpendicular to an extending direction of reinforcing fiber yarns is observed, a rate te/tc of a thickness of a reinforcing fiber yarn te at an end portion in the width direction of the reinforcing fiber yarn to a thickness of a reinforcing fiber yarn tc at a center portion in the width direction of the reinforcing fiber yarn is in a range of 0.3 to 1.

38. The reinforcing fiber substrate according to claim 28, wherein said substrate is used for formation of a preform in which a plurality of substrates are stacked and integrated.

39. A composite material characterized in that said composite material is formed by impregnating a resin into a reinforcing fiber substrate, which comprises a reinforcing fiber group arranged with reinforcing fiber yarns in parallel to each other in one direction, in which spacer yarns each having a concave/convex surface are arranged between said reinforcing fiber yarns, and in which a resin material is adhered at 2 to 20 % by weight at least to one surface of said reinforcing fiber group, and the reinforcing fiber volume fraction V_f of said composite material calculated from a thickness of said composite material is

in a range of 50 to 65 %.

40. The composite material according to claim 39, wherein a maximum cross-sectional waviness of a layer of a reinforcing fiber substrate in a section of said composite material is 0.3 mm or less.

41. A method for producing a reinforcing fiber substrate formed by at least reinforcing fiber yarns arranged in parallel to each other in one direction and including a resin material, whose main constituent is a thermoplastic resin, provided at 2 to 15 % by weight at least on one surface of said reinforcing fiber substrate, said method comprising the steps of:

(A) a drawing step for drawing said reinforcing fiber yarns;

(B) a substrate forming step for forming a substrate form;

(C) a pressing step for pressing the substrate and controlling the thickness of the substrate so that the reinforcing fiber volume fraction V_{pf} of said reinforcing fiber substrate calculated from a thickness of said reinforcing fiber substrate, which is determined based on JIS-R7602, is in a range of 40 to 60 %;

(D) a cooling step for cooling the substrate and fixing the resin material; and

(E) a winding step for winding the substrate.

42. The method for producing a reinforcing fiber substrate according to claim 41, wherein, in said pressing step (C), the thickness of the substrate is smallened by continuously applying a pressure to the substrate via a roller.

43. The method for producing a reinforcing fiber substrate according to claim

41, wherein, in said pressing step (C), the surface of a roller or a releasing sheet directly brought into contact with the substrate has a concave/convex form of 5 to 500 μm.

44. A method for producing a composite material comprising the steps of:

preparing a reinforcing fiber substrate, formed by at least reinforcing fiber yarns arranged in parallel to each other in one direction and including a resin material, whose main constituent is a thermoplastic resin, provided at 2 to 15 % by weight at least on one surface of said reinforcing fiber substrate, by a method comprising the steps of:

(A) a drawing step for drawing said reinforcing fiber yarns;

(B) a substrate forming step for forming a substrate form;

(C) a pressing step for pressing the substrate and controlling the thickness of the substrate so that the reinforcing fiber volume fraction V_{pf} of said reinforcing fiber substrate calculated from a thickness of said reinforcing fiber substrate, which is determined based on JIS-R7602, is in a range of 40 to 60 %;

(D) a cooling step for cooling the substrate and fixing the resin material; and

(E) a winding step for winding the substrate;

molding a composite material, the reinforcing fiber volume fraction V_f of which calculated from a thickness of said composite material is in a range of 50 to 65 %, by placing said prepared reinforcing fiber substrate in a cavity formed by a mold and a bag material and impregnating a matrix resin into the substrate by reducing a pressure in the cavity.

45. The method for producing a composite material according to claim 44, wherein said composite material is molded so that a maximum cross-sectional waviness of a layer of a reinforcing fiber substrate in a section of said composite material is 0.3 mm or less.